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Passage Conditions and Counts of Fish at the Snake Island Fishway, Little Falls Dam, Potomac River, Md., 1960-63

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SPECIAL SCIENTIFIC REPORT–FISHERIES No. 565

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Passage Conditions and Counts of Fish at the Snake Island Fishway, Little Falls Dam, Potomac River, Md., 1960-63

By

PAUL R. NICHOLS

UNITED STATES FISH AND WILDLIFE SERVICE
SPECIAL SCIENTIFIC REPORT--FISHERIES No. 565

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Passage Conditions and Counts of Fish at the Snake Island Fishway, Little Falls Dam, Potomac River, Md., 1960-63

By

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ABSTRACT

Resident fish such as sucker, carp, channel catfish, bluegill, and black crappie travelled through the fishway, but apparently no anadromous fish ascended the river far enough to reach the fishway. It is possible that: (1) the runs of anadromous fish are now at such a low level that the spawning area above Little Falls is not needed as in former years; (2) the stocks with the instinct to move above Little Falls which were blocked from their natural spawning ground when the Little Falls Dam was rebuilt in 1949 have since disappeared; and (3) the rapids between Chain Bridge and the fishway may deter the upstream progress of migrating fish.

Success in reestablishing runs of anadromous fish above Little Falls may require the planting of fertilized eggs and adult fish in the upper river and the construction of fish-passage facilities at the rapids above Chain Bridge. Successful hatching of shad eggs and the collection of young shad above Little Falls indicate that the river is suitable for the restoration of this species.

INTRODUCTION

The Potomac River originates on the boundary between West Virginia and Maryland and flows 290 miles southeasterly before it empties into Chesapeake Bay. Fluvial characteristics disappear at Washington, D.C., the head of navigation. Below Washington, the river is broad and sluggish, forming one of the largest estuaries on the Atlantic Coast.

Between Washington and Great Falls, which is 15 miles upstream and has always been a barrier to the upstream movement of fish, the river passes over the "fall line." This area has numerous shoals and several small falls. The river channel becomes constricted about 5 miles above Washington, at which point is an outcropping of bedrock at Little Falls (fig. 1).

Among the most valuable fish of the Potomac River are those that spend most of their lives in salt or brackish water, but require fresh water for spawning and nursery grounds. They include American shad, Alosa sapidissima; hickory shad, A. mediocris; alewife, A. pseudoharengus; blueback herring, A. aestivalis; striped bass, Roccus saxatilis; and white perch, R. americanus. Large numbers of these fish move up the Potomac each spring toward their natural spawning grounds. Before 1942 some fish moved upstream as far as Great Falls, particularly when a dam at Little Falls, constructed in 1831, contained breaks from ice damage during the preceding winter. The Little Falls Dam was rebuilt in 1943-49; after completion it obstructed the upstream movement of fish beyond this point.

Because the reconstructed Little Falls Dam blocked the upstream movement of fish, the conservation agencies of Maryland and Virginia, together with the Fish and Wildlife Service, began to explore means whereby the 10-mile area between Little Falls and Great Falls could again be used by anadromous fish. An additional complication was the plan of the U.S. Army Corps of Engineers to construct a new dam at Little Falls upstream from the old dam. The new structure was to be a concrete overflow 9-foot-high dam, designed to maintain a pool from which the District of Columbia could draw additional water. Efforts by the conservation agencies to get fish passage facilities at Little Falls were successful; the new dam, including the Snake Island fishway, was completed in the fall of 1959.

[1] Present address: Bureau of Commercial Fisheries, Washington, D.C. 20240.

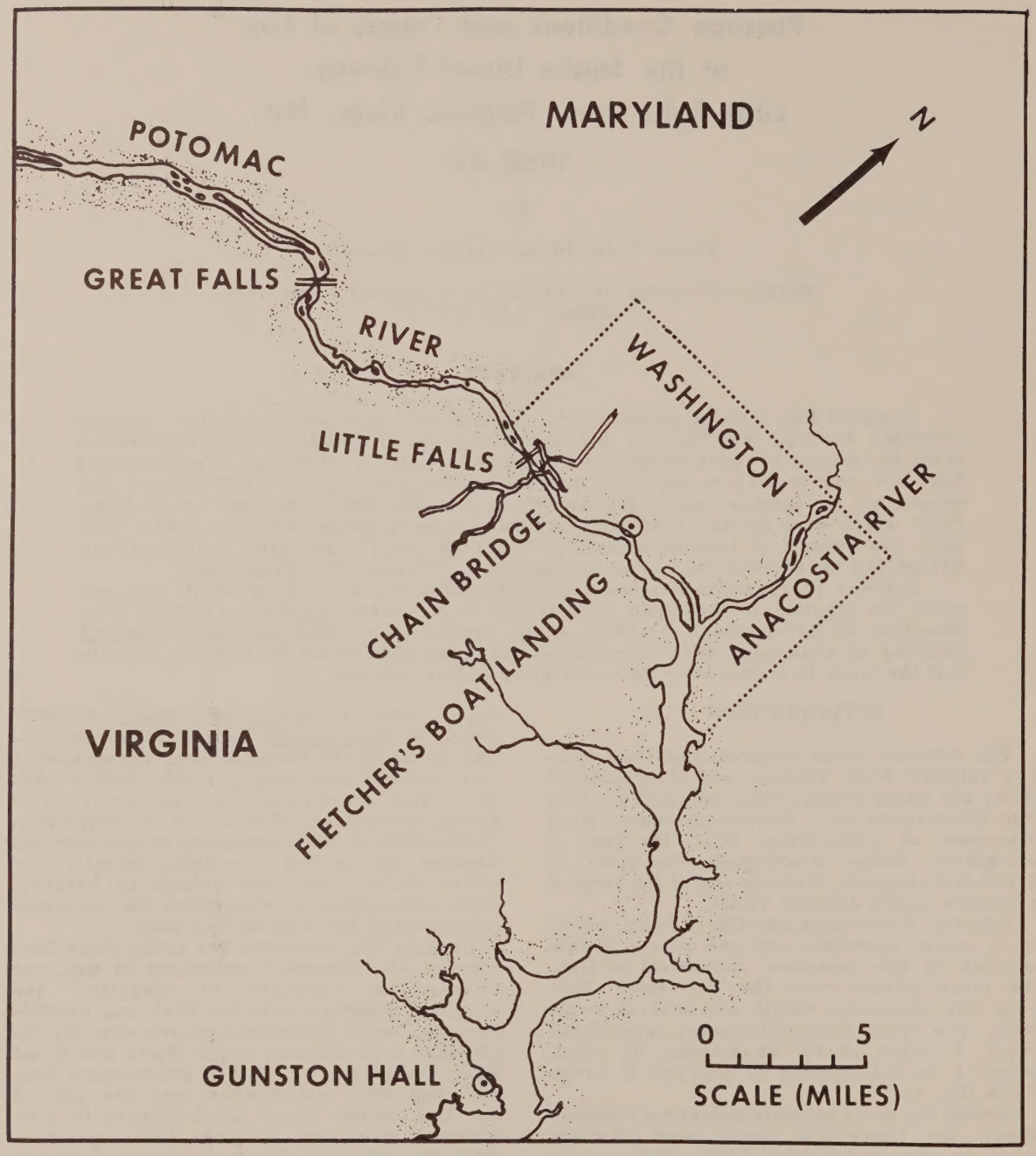

Figure 1.--Map of the study area.

The Bureau of Commercial Fisheries began studies to evaluate the passage of fish by the new fishway in the spring of 1960 and continued observations through 1963. This paper is a report of the observations made during this period.

DESIGN OF THE SNAKE ISLAND FISHWAY

The Snake Island fishway is located on Snake Island, near midstream at Little Falls Dam (fig. 2). This vertical-baffle fishway has 12 pools, each 10 feet long by 8 feet wide,

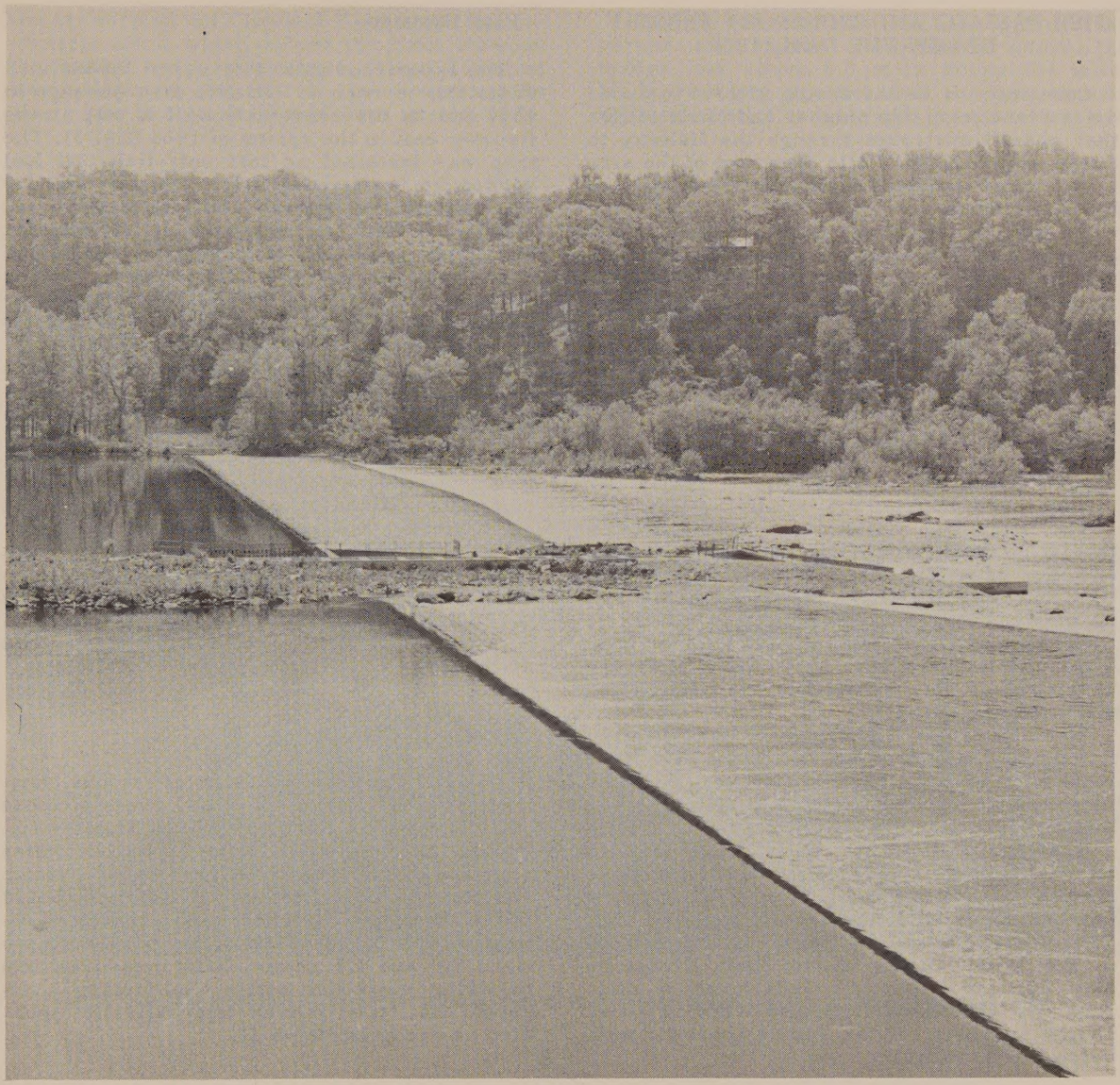

Figure 2.--Little Falls Dam on the Potomac River in the spring of 1963.

with a 3/4-foot drop between pools. This type of fishway was first developed by the International Pacific Salmon Fisheries Commission for use at Hells Gate on the Frazer River in British Columbia, Canada. Since its development many facilities of this design installed on west coast rivers have proved effective in passing fish over barriers (U.S. Army Corps of Engineers, 1964). A major advantage is that they can operate over a wide range of water flows and, therefore, are more adaptable and require less attention than certain other types of fishways. The Snake Island fishway is designed to be effective at river flows of 3,000 to 32,000 c.f.s. (cubic feet per second). The fishway and attraction chamber are about 360 feet long; the fishway itself is 120 feet long. The attraction chamber is 45 feet wide and 120 feet long; additional water is introduced through gratings in the floor of the channel to maintain velocities of 2 to 3 f.p.s. (feet per second). Little Falls Dam is 1,200 feet long; water spills over the full length of the dam at all times.

FISH PASSAGE AND THE SPORT FISHERY BELOW THE DAM, 1960

Observations in the spring of 1960 included determination of the number and kinds of fish that passed upstream through the fishway to areas above Little Falls Dam and of the size of the sport fisheries for anadromous species below the dam.

To aid in the observation of the number and kinds of fish using the fishway, an adjustable inclined screen was installed in the upstream exit channel. This structure forced the fish to swim near the water surface where they could be counted and identified. Observations were made from April 29 to June 15 (33 days), during 169 hours between 6:30 a.m. and 8 p.m. No fish were seen using the fishway. Water temperature at the fishway exit ranged from 11.6° to 23.3° C., dissolved oxygen from 6.4 to 1.0 p.p.m. (parts per million), and pH from 6.8 to 7.6

The attraction channel and waters immediately below the dam were examined periodically for fish. Among the fish seen were carp, Cyprinus carpio; suckers, Moxostoma spp.; channel catfish, Ictalurus punctatus; crappies, Pomoxis spp.; and sea lampreys, Petromyzon marinus. Suckers and carp were observed passing over the dam between the fishway and the Maryland shore.

When observations began at the fishway, fishermen using drag hooks and dip nets were catching large numbers of alewives, blueback herring, and white perch immediately below and above Chain Bridge, about 1 mile downstream from Little Falls; they continued to catch fish until mid-June. Several immature striped bass were caught by hook and line near Chain Bridge the first 2 weeks in May. The first shad were caught by dip netters in the lower rapids above Chain Bridge on May 20, and about 200 were taken by mid-June. No anadromous species were reported caught upstream of the rapids about 0.8 mile below the fishway.

FISH PASSAGE, FISHWAY HYDRAULICS, AND UPSTREAM MOVEMENTS OF ANADROMOUS FISH, 1961

Observations were made in the spring of 1961 to determine the number and kinds of fish that passed upstream through the fishway, the hydraulics of the fishway, and the upstream limit of migration by anadromous species.

Fish Passage

The experience gained by use of the inclined adjustable screen to observe fish passage in 1960 led to the construction of a trap in the fishway exit in the spring of 1961 (fig. 3). The trap was installed so that only fish that had passed up the fishway were trapped; thereby the use of the fishway could be determined exactly without an observer in attendance. The trap consisted of a vertical baffle and drop gate in the entrance channel, a removable screen in the exit channel, and a false bottom lift attached to a hand-operated hoist mounted on the fishway grating.

Observations began May 3 and continued to June 7. The trap was lifted 206 times during these 36 days at various time intervals between 7 a.m. and 8 p.m. No anadromous species were seen in the attraction channel. Resident species used the fishway under various combinations of attraction flow. The fish count through the trap was 10 suckers; 6 bluegills, Lepomis macrochirus; 2 channel catfish; and 5 carp (table 1). Minimum and maximum water temperatures at the fishway exit during the period were 12.7° and 23.3° C. Secchi disk readings at 10 a.m. ranged from 10 to 41 inches.

Fishway Hydraulics

The fishway was operated at various combinations of attraction flow over a mean daily river discharge of 6,540 to 33,600 c.f.s. It was operated with 4 to 10 needle weirs removed from the auxiliary water system and with none to 3 stoplog openings closed in the attraction chamber. Minimum and maximum drops in water elevation between pools were 7.8 and 8.9 inches. Daily measurements of water elevation within the facility indicated that the fishway hydraulically operated as designed (table 2).

Upstream Movement of Anadromous Fish

Observations began at the fishway on May 3. At this time, commercial fishermen were catching shad at Gunston Hall, Va., about 25 miles downstream from Little Falls; the fishery continued until late May. In May and June large numbers of alewives, blueback herring, and white perch were taken by dip net and drag hooks near Chain Bridge and in

the tailrace of the Corps of Engineers' hydroelectric plant which enters the river between the bridge and rapids above. About 250 shad were taken by dip net in the lower rapids above the bridge from mid-May to mid-June.

Anadromous fish did not ascend the river beyond the rapids immediately above the bridge and about 0.8 mile below the falls. Many resident species but no anadromous species were caught with haul seines and

Figure 3.--Trap installed in the upstream exit channel of the Snake Island fishway to observe passage of fish.

Table 1.--Number and kinds of fish passed by Snake Island fishway in the Potomac River, spring of 1961

Date	Operative conditions					Fish passed			
	Light penetration	8 a.m. water temperature	Needle weirs out	Stoplog openings closed	Fishway trap lifts	Sucker	Bluegill	Channel catfish	Carp
	Inches	° C.	Number	Number	Number	Number	Number	Number	Number
May 3	28.0	12.7	9	------	4	------	------	------	------
4	27.5	13.8	9	------	7	------	------	------	------
5	29.0	14.4	9	------	8	------	------	------	------
6	29.0	14.4	9	------	6	------	------	------	------
7	29.0	14.4	9	------	4	------	------	------	------
8	29.0	14.4	9	------	8	------	------	------	------
10	24.0	16.6	9	------	6	------	------	------	------
11	25.0	16.1	9	------	3	------	------	------	------
12	10.0	15.6	9	------	5	------	------	------	------
13	16.0	16.1	9	------	4	------	------	------	------
15	14.5	16.1	9	------	5	------	------	------	------
17	16.0	15.6	9	------	5	------	------	------	------
19	23.5	16.1	9	------	8	------	------	------	------
20	27.5	16.1	9	------	4	------	------	------	------
21	31.5	16.1	9	------	4	------	------	------	------
22	32.0	16.6	9	------	9	------	------	------	------
23	37.0	16.6	9	------	7	------	------	------	------
24	38.5	17.2	7	------	7	------	2	------	------
25	39.0	17.7	7	------	5	------	------	------	1
26	40.0	20.0	7	2	4	------	------	------	------
27	39.0	17.8	7	2	3	------	------	------	------
28	40.0	21.1	7	2	5	------	------	------	------
29	39.0	17.8	7	2	9	2	2	------	------
30	39.5	16.7	7	2	7	------	------	------	------
31	41.0	17.2	7	3	10	2	1	------	------
June 1	40.0	18.3	5	3	8	------	------	------	1
2	39.5	20.5	4	3	18	1	1	------	1
3	39.5	22.2	4	3	6	2	------	------	1
4	40.0	22.2	10	3	6	------	------	------	------
5	40.0	22.7	10	3	6	------	------	------	------
6	41.0	23.3	5	3	8	2	------	1	-----
7	41.0	23.3	5	3	7	1	------	1	1
Total					206	10	6	2	5

Table 2.--Daily 10 a.m. water elevations in Snake Island fishway, Potomac River, and provisional mean river discharge in c.f.s. (cubic feet per second) at gaging station 1 mile upstream from Little Falls, 1961

[Elevation measurements made to nearest 0.5 inch and converted to feet and hundredths of a foot]

Date	Tail-water 1/	Attraction water	Pools											Fish exit	Head-water 2/	Mean drop between pools 3/	Mean daily river discharge 4/
			1	2	3	4	5	6	7	8	9	10	11				
May 3	6.33	6.25	6.58	7.17	7.75	8.42	9.08	9.83	10.58	11.33	11.92	12.75	13.62	14.46	14.67	0.73	17,500
4	6.21	6.08	6.67	7.08	7.75	8.42	9.17	9.83	10.58	11.25	12.00	12.67	13.50	14.29	14.58	0.72	16,700
5	6.12	6.04	6.54	7.08	7.63	8.25	9.08	9.75	10.46	11.17	11.92	12.67	13.46	14.21	14.50	0.72	15,800
6	5.92	5.75	6.25	6.75	7.42	8.17	8.92	9.58	10.33	11.00	11.79	12.50	13.29	14.12	14.38	0.73	14,600
7	5.79	5.67	6.25	6.75	7.42	8.00	8.62	9.33	10.17	10.96	11.67	12.42	13.21	14.04	14.29	0.73	13,800
8	5.88	5.79	6.33	6.83	7.50	8.17	9.08	9.58	10.33	11.08	11.83	12.50	13.29	14.12	14.38	0.73	14,200
9	----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	----	15,900
10	6.50	6.42	6.96	7.38	8.00	8.58	9.25	9.92	10.75	11.46	12.12	12.83	13.62	14.54	14.79	0.72	19,300
11	6.50	6.42	7.00	7.46	8.00	8.58	9.29	10.00	10.75	11.46	12.17	12.88	13.71	14.54	14.83	0.71	19,400
12	6.58	6.58	7.12	7.58	8.08	8.67	9.42	10.08	10.79	11.50	12.25	12.96	13.75	14.58	14.88	0.70	19,600
13	6.75	6.71	7.21	7.67	8.17	8.79	9.50	10.08	10.83	11.58	12.38	13.04	13.79	14.67	14.96	0.72	24,100
14	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	30,800
15	8.00	7.92	8.50	8.83	9.33	9.83	10.42	10.92	11.67	12.33	13.08	13.71	14.46	15.29	15.96	0.65	33,600
16	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	28,900
17	7.00	7.00	7.50	7.92	8.42	9.00	9.67	10.33	11.08	11.75	12.50	13.21	13.92	14.79	15.17	0.68	23,200
18	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	19,800
19	6.42	6.29	6.88	7.38	7.92	8.54	9.21	9.92	10.67	11.42	12.17	12.88	13.62	14.46	14.71	0.71	17,400
20	6.08	6.12	6.54	7.08	7.67	8.29	9.00	9.62	10.38	11.17	11.88	12,58	13.33	14.17	14.46	0.71	15,400
21	5.83	5.75	6.33	6.88	7.46	8.12	8.83	9.50	10.25	11.00	11.75	12.46	13.25	14.08	14.33	0.72	14,100
22	5.75	5.75	6.33	6.79	7.33	8.00	8.75	9.46	10.21	10.96	11.71	12.38	13.17	14.00	14.25	0.72	13,400
23	5.54	5.58	6.00	6.58	7.21	7.83	8.58	9.25	10.00	10.75	11.46	12.29	13.12	13.96	14.21	0.73	12,000
24	5.38	5.38	5.92	6.50	7.08	7.79	8.54	9.25	9.96	10.67	11.42	12.17	12.96	13.79	14.04	0.73	11,200
25	5.25	5.25	5.83	6.42	7.00	7.62	8.38	9.12	9.83	10.58	11.38	12.08	12.83	13.71	13.96	0.73	10,400
26	5.08	5.08	5.62	6.21	6.88	7.54	8.29	9.08	9.79	10.54	11.25	12.00	12.75	13.54	13.83	0.73	9,660
27	5.04	5.08	5.62	6.17	6.75	7.46	8.21	8.92	9.67	10.42	11.17	11.96	12.67	13.50	13.79	0.73	9,310
28	4.92	4.88	5.50	6.08	6.75	7.42	8.21	8.92	9.67	10.42	11.17	11.92	12.67	13.50	13.71	0.74	8,580
29	4.83	4.83	5.46	6.04	6.71	7.38	8.12	8.83	9.58	10.38	11.17	11.88	12.62	13.46	13.67	0.74	8.120
30	4.75	4.79	5.46	6.04	6.67	7.38	8.12	8.88	9.67	10.38	11.17	11.92	12.62	13.46	13.67	0.74	7,800
31	4.71	4.75	5.42	6.00	6.67	7.42	8.12	8.88	9.62	10.38	11.17	11.88	12.58	13.46	13.62	0.75	7,380
Mean	5.88	5.83	6.42	6.92	7.50	8.17	8.83	9.54	10.29	11.04	11.79	12.50	13.29	14.12	14.38	0.72	16,470
June 1	4.58	4.71	5.42	6.00	6.62	7.33	8.08	8.83	9.62	10.38	11.17	11.83	12.58	13.42	13.58	0.74	7,020
2	4.50	4.62	5.25	5.92	6.58	7.29	8.04	8.83	9.58	10.33	11.12	11.83	12.58	13.38	13.54	0.75	6,900
3	4.42	4.54	5.17	5.83	6.54	7.29	8.04	8.75	9.50	10.29	11.08	11.79	12.50	13.33	13.50	0.75	6,540
4	4.42	4.50	5.12	5.88	6.54	7.25	8.04	8.83	9.58	10.33	11.04	11.75	12.54	13.33	13.50	0.75	6,540
5	4.42	4.50	5.17	5.83	6.58	7.29	8.00	8.75	9.50	10.29	11.04	11.75	12.50	13.33	13.50	0.75	6,720
6	4.79	5.00	5.50	6.21	6.75	7.42	8.21	9.00	9.67	10.42	11.17	11.92	12.71	13.50	13.67	0.73	7,860
7	4.75	4.96	5.50	6.25	6.75	7.42	8.17	8.96	9.67	10.42	11.17	11.79	12.67	13.54	13.58	0.73	7,680
Mean	4.54	4.71	5.33	6.00	6.62	7.33	8.08	8.83	9.58	10.33	11.12	11.83	12.58	13.42	13.54	0.74	7,037

1/ Water elevation influenced by inflow into attraction channel at downstream end of attraction wall from spillage over the dam adjacent to fishway. 2/ Water elevation influenced by trap installation in fish exit channel. 3/ Average for pools 2 through 11, because of auxiliary water influence on water elevation in pool 1. 4/ Furnished by the U.S. Geological Survey, Water Resources Division, College Park, Md.

dip nets in the fishway attraction channel (fig. 4) and throughout the river from the falls downstream to the bridge.

FISH PASSAGE AND UPSTREAM MOVEMENT OF ANADROMOUS FISH, 1962

Observations were continued in the spring of 1962 near Little Falls to determine the upstream passage of fish through the Snake Island fishway and to gather additional information on the upstream migration by anadromous fishes.

Fish Passage

The fishway was operated on April 30 and May 5 to 31. The fishway trap was lifted 68 times during these 27 days at various time intervals between 7 a.m. and 9 p.m. Fish counted through the trap included 14 suckers; 18 bluegills; 63 catfish; and 1 carp (table 3). No anadromous fish were trapped or seen in the fishway system. Many suckers and carp were observed passing over the dam between Snake Island and the Maryland shore.

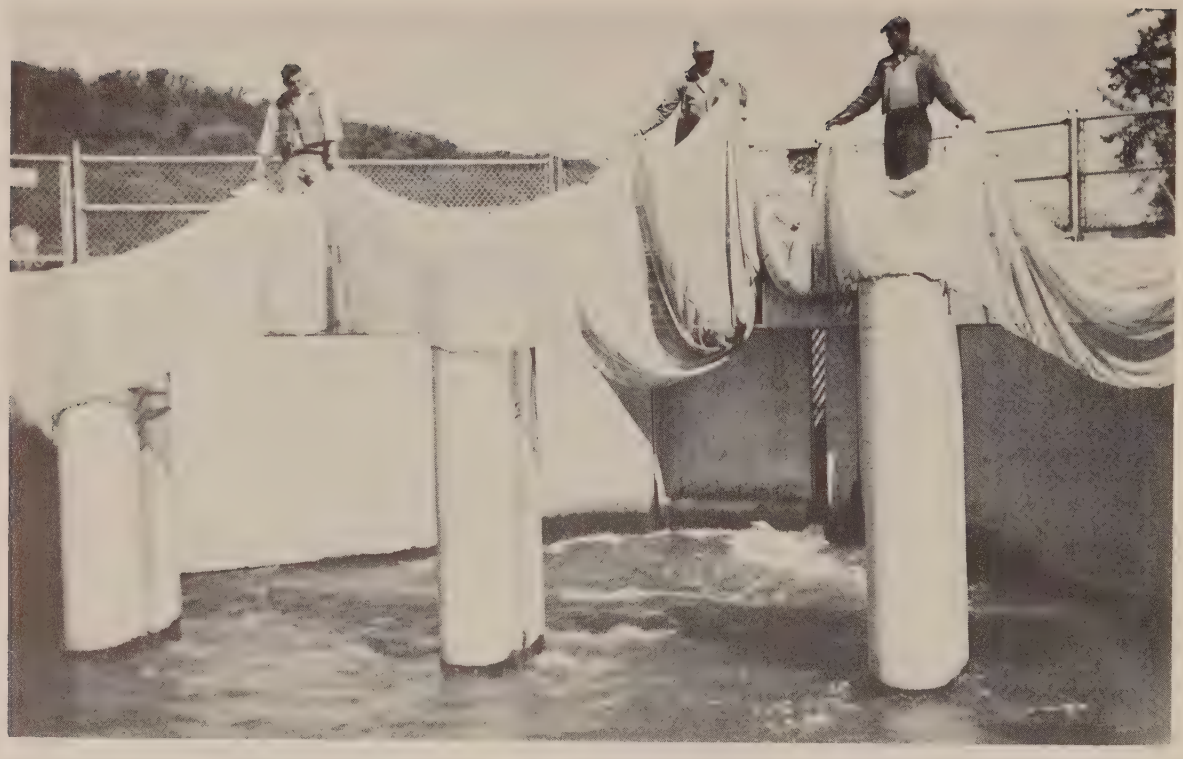

Figure 4.--Lowering haul seine into attraction channel to sample fish at Snake Island fishway, Potomac River.

Upstream Movement of Anadromous Fish

The commercial and sport fisheries were canvassed from Little Falls to the U.S. Highway 301 bridge, a distance of about 60 miles. Pound netters fished immediately above this bridge from March 20 to May 10. The daily catch ranged from 20 to 50 shad per net in March and April and 3 to 15 per net in May. The catches of other anadromous fish were substantial, but no estimate was made of the numbers taken. Drift gill netters near Gunston Hall fished in April and May. Their daily shad catch ranged from 12 to 165 fish; the larger catches were taken in mid-May. Dip net fishermen took an estimated 500 shad from May 5 to June 1 in the rapids above Chain Bridge. Rod-and-reel fishermen caught a few shad near Fletcher's Boat Landing about 3 miles below the bridge, but no estimate was made of the numbers taken. They also caught an estimated 300 immature striped bass, 7 to 12 inches fork length, between Chain Bridge and the rapids immediately above the bridge from May 15 to 30. Alewives, blueback herring, and white perch were plentiful near the bridge and in nearby tributary streams from the first of April to the end of May.

Experimental fishing with dip nets between Little Falls and the rapids above Chain Bridge produced two male American shad, one on May 18 and the other on May 22. Several resident fishes also were taken.

A survey of the river channel from Little Falls to the rapids above Chain Bridge revealed no obstructions to the upstream movement of fish in this section of the river.

FISH PASSAGE, EXPERIMENTS WITH ANADROMOUS FISH, AND STUDY OF THE RIVER ABOVE THE DAM, 1963

Field studies were continued at the Snake Island fishway in the spring of 1963 to note the behavior of anadromous fish placed in holding facilities in the fishway attraction chamber, to observe the upstream passage of fish through the fishway, and to determine the suitability of the Potomac River above Little Falls for the hatching of shad eggs.

Fish Passage

The fishway was operated for fish passage from April 25 to 28 and May 24 to June 12.

Table 3.--Number and kinds of fish passed by Snake Island fishway, Potomac River, spring of 1962

Date	Operative conditions				Fish passed			
	8 a.m. water temperature	Needle weirs out	Stoplog openings closed	Fishway trap lifts	Sucker	Bluegill	Channel catfish	Carp
	°C.	Number	Number	Number	Number	Number	Number	Number
April 30	15.5	5	2	1	2	------	1	------
May 7	17.7	5	1	1	------	------	------	------
8	17.2	5	1	3	------	------	------	------
9	15.6	5	1	2	1	1	------	------
10	15.5	5	1	4	2	------	1	1
11	15.5	5	1	2	------	------	1	------
12	15.7	5	1	3	------	------	------	------
14	18.8	6	1	5	2	1	1	------
15	20.0	6	1	6	------	------	------	------
16	21.1	6	1	5	1	2	1	------
17	22.2	6	1	5	------	1	1	------
18	23.3	6	1	4	2	------	------	------
21	23.3	6	2	4	1	------	2	------
22	22.2	6	2	3	1	1	2	------
23	22.2	8	2	2	------	------	2	------
24	22.7	8	2	4	------	------	10	------
25	23.3	8	2	2	------	6	8	------
26	23.8	8	2	2	2	------	2	------
27	23.3	8	2	3	------	1	16	------
28	22.2	8	2	1	------	------	2	------
29	23.3	8	2	1	------	2	3	------
30	23.3	8	2	3	------	1	6	------
31	23.3	8	2	2	------	2	4	------
Total				68	14	18	63	1

Fish counted through the fishway trap included: 1 sucker, 2 bluegills, and 14 channel catfish (table 4). No anadromous species were trapped or seen in the fishway system.

Fish Behavior in Holding Facility

From April 22 to 24 and April 29 to May 23, we observed the behavior of anadromous fish placed in a holding pen immediately below the fishway entrance. The pen was made by placing a wire screen in one of the stoplog openings, while the stoplogs were left in place in the other openings (fig. 5). The only escapement route for captive fish was upstream through the fishway.

The number of each species held in the pen on any 1 day was: 1 to 43 American shad

Table 4.--Number and kinds of fish passed by Snake Island fishway, Potomac River, spring of 1963

Date	Operative conditions				Fish passed		
	8 a.m. water temperature	Needle weirs out	Stoplog openings closed	Fishway trap lifts	Sucker	Bluegill	Channel catfish
	° C.	Number	Number	Number	Number	Number	Number
April 25	16.1	8	2	1	------	------	------
26	16.1	8	2	1	------	------	------
27	16.1	8	2	1	------	------	------
28	16.7	8	2	1	------	------	------
May 24	19.4	8	3	1	------	------	------
25	19.4	8	3	1	------	------	------
26	18.9	8	3	1	------	------	------
27	20.0	8	3	1	1	------	2
28	18.9	8	3	1	------	------	------
30	21.1	8	3	1	------	------	------
31	22.2	8	3	1	------	------	------
June 1	22.8	10	3	1	------	------	------
2	21.1	10	3	1	------	------	------
3	20.0	10	3	1	------	------	------
4	20.6	10	3	1	------	1	------
5	21.7	10	3	1	------	------	------
6	22.2	10	3	1	------	------	------
7	22.8	10	3	1	------	------	3
8	21.7	10	3	1	------	------	4
9	22.8	10	3	1	------	------	1
11	24.4	10	3	1	------	------	------
12	24.4	10	3	1	------	1	4
Total				22	1	2	14

over a 27-day period; 2 to 20 striped bass over a 20-day period; 1 to 23 alewives over a 17-day period; 7 to 17 white perch over a 12-day period; and 3 hickory shad over a 5-day period (table 5). American shad lived 1 to 15 days in the holding pen (average of 4 days), striped bass 1 to 17 days (average 6 days), white perch and alewives 1 to 9 days (average 4 days), and hickory shad 5 days. Water temperature in the holding pen ranged from 13.3° to 20.6° C.

During the experiment, the fishway was operated with various combinations of attraction flow. We made daily observations of fish behavior and lifted the trap in the fishway exit 67 times. None of the fish placed in the pen was trapped or seen in the fishway transportation pools. All species made random movements in the pen but at no time did the fish appear to be schooled. American shad usually swam near the surface in the calm waters of the attraction chamber; the other

Table 5.--Operative conditions and number of anadromous fish held in the attraction chamber at the Snake Island fishway, Potomac River, spring of 1963

Date	Operative conditions			Species held				
	Water depth transportation channel	Time operated	8 a.m. water temperature	American shad	Striped bass	Alewives	White perch	Hickory shad
	Inches	Hours	° C.	Number	Number	Number	Number	Number
April 22	46	24	15.6	4	6	21	12	------
23	45	24	16.1	4	6	18	12	------
24	45	24	16.1	4	6	18	12	------
29	30	1	16.1	3	------	16	14	3
	14	4	16.1	3	------	16	14	3
	42	19	16.1	3	------	16	14	3
April 30	42	24	16.1	3	------	16	14	3
May 1	42	24	13.3	3	------	16	14	3
2	42	24	11.7	1	------	11	8	3
3	41	24	13.3	1	13	22	17	3
4	41	24	14.4	1	13	10	11	------
5	41	24	16.1	1	13	11	10	------
6	41	24	18.3	1	20	15	17	------
7	40	24	19.4		15	3	7	------
8	40	24	18.9	1	8	1	------	------
9	40	24	20.6	8	6	1	------	------
10	40	24	20.6	8	6	1	------	------
11	40	24	20.0	4	4	1	------	------
12	39	24	20.0	4	4	1	------	------
13	39	24	20.6	18	2	------	------	------
14	14	24	20.0	36	2	------	------	------
15	20	8	20.0	43	2	------	------	------
	39	16	20.0	43	2	------	------	------
16	24	24	20.0	41	2	------	------	------
17	32	24	20.0	31	2	------	------	------
18	36	17	20.0	22	2	------	------	------
19	40	19	20.0	9	2	------	------	------
20	40	24	20.6	5	------	------	------	------
21	40	24	20.6	4	------	------	------	------
22	40	24	20.6	1	------	------	------	------
23	41	24	19.4	1	------	------	------	------

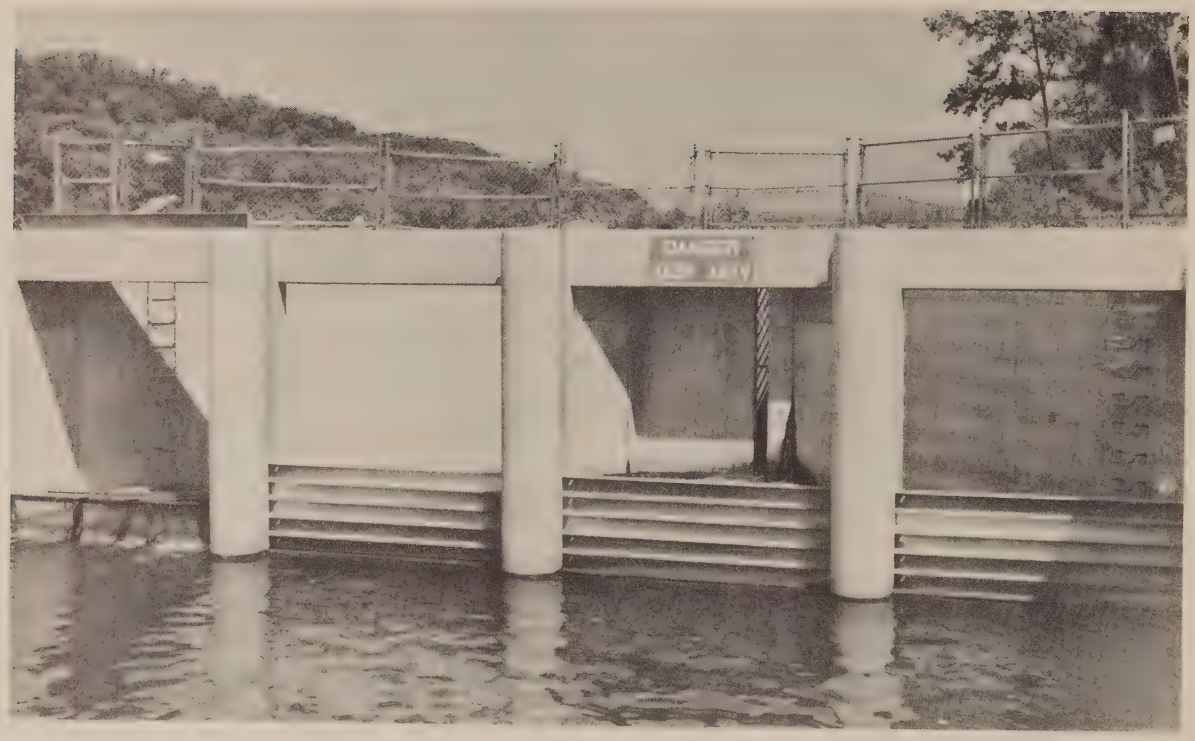

Figure 5.--Holding pen for experimental fish in Snake Island fishway attraction chamber.

species stayed nearer the bottom. Occasionally two or three shad left the calm waters, moved into the attraction flow, and swam upstream in the current toward the fishway entrance, only to veer off into the calm water about 2 feet short of the fishway entrance. The behavior of the fish did not change significantly during the various combinations of attraction flow.

Study of the River Above the Dam

Approximately 490,000 fertilized shad eggs, obtained May 24 to June 12 from commercial fishermen at Gunston Hall, were distributed above Little Falls in hatching boxes of various colors (fig. 6). About 50 percent of the eggs were placed in boxes about 2 miles above Little Falls, 15 percent about 6 miles above Little Falls, and 35 percent at Great Falls. Survival of eggs to the eyed stage ranged from 20 to 85 percent and averaged 58 percent. Survival of eggs to the eyed stage in black and unpainted boxes averaged 73 percent, but in white-painted boxes averaged 48 percent. Peak hatching of all lots occurred in about 68 hours at water temperatures of 23° to 25° C. At water temperatures of 18° to 20° C., eggs hatched in about 88 hours. Hatching survival did not differ among locations.

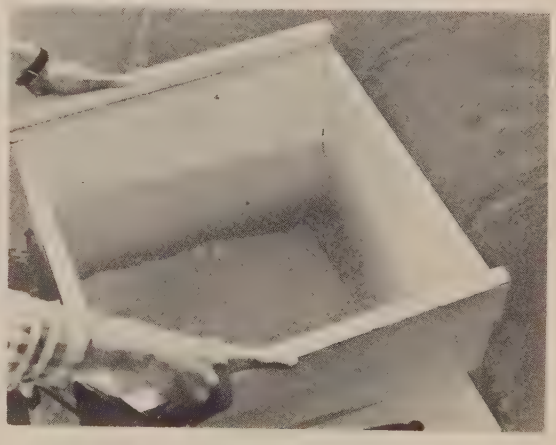

Figure 6.--Shad eggs in hatching boxes above Little Falls, Potomac River.

A search was made for young shad August 20-23 at the hatching sites above Little Falls Dam. Shadlike feeding activity was seen at hatching sites about 2 and 4 miles above the dam, but not at the other sites. Boulders and shoal areas prevented sampling with trawls in the area where the fish were active. Seven young shad, from 2.9 to 3.5 inches fork length, were collected by trawl in the

pool above Little Falls Dam. Undoubtedly these fish were from shad eggs hatched above the dam.

CONCLUSIONS

Our observations at the Snake Island fishway during four seasons proved that it passed resident species such as suckers, carp, catfish, bluegills, and crappies. No anadromous fishes, so far as could be determined, ascended the river to the fishway. Measurements of water flow and levels in the fishway indicated that it operated as designed. I believe that since the resident fishes negotiated the fishway, the anadromous species also surely would have done so if they had been present.

The failure of the experimental fish to use the fishway is unexplained. Possibly the holding facility in the attraction chamber was too small, and therefore the fish remained excited and unschooled. It also is possible that the presence of several species in the attraction chamber at one time may have prevented normal reorientation and behavior. Mortality in the holding facility was unusually high; it may be necessary in future holding experiments to use the entire attraction channel to hold experimental fish. This arrangement would aprovide a holding facility about 120 feet long by 45 feet wide. Attraction flow could continue to be regulated by the stoplog structure.

I feel that the attempt to pass shad and other anadromous fish at Little Falls failed, not through any fault of the fishway, but as a result of failure of the fish to migrate that far upstream. Why anadromous fishes do not ascend the river to the fishway is not readily apparent. It is possible that: (1) the runs, particularly of American shad, are at such a low level that the spawning area above Little Falls Dam is not needed, and therefore the fish are not compelled to move as far upstream as in former years; (2) the stocks with the urge to move above Little Falls Dam (if they existed as a distinct genetic unit), which were blocked from their natural spawning grounds when the dam was rebuilt (1943-49), have since disappeared; and (3) the rapids immediately above Chain Bridge may deter the upstream progress of migrating fish, at least at some river discharges.

The commercial catch of shad in the Potomac River has declined (fig. 7), with minor fluctuations, from a peak of more than 3 million pounds in 1922 to less than one-quarter of a million pounds in 1963 (Powers, 1958; Lyles, 1965). The establishment of runs beyond Little Falls Dam could aid in the restoration of the fishery. Successful passage of shad by the fishway could produce

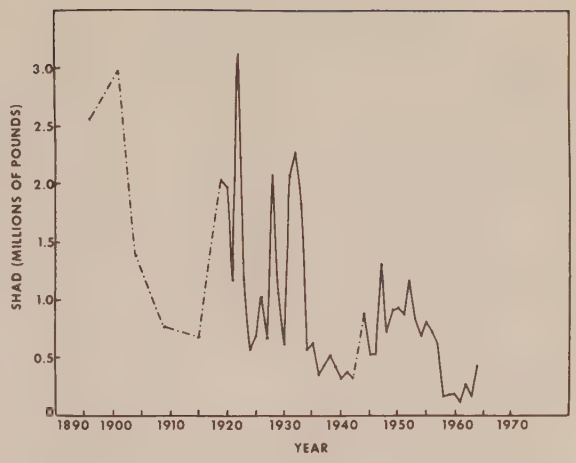

Figure 7.--Commercial shad catch, Potomac River, 1890-1964.

benefits after a period of 8 to 10 years from the added spawning habitat above Little Falls.

In the framing of plans to restore runs of anadromous fish, particularly American shad and striped bass, to the area above Little Falls, it is important to consider that each river, possibly each spawning area, supports a self-perpetuating population that returns each successive generation to spawn in the same area (Mansueti, 1961; Nichols, 1960; Talbot and Sykes, 1958). The upper limits of the present spawning grounds of shad and striped bass are near Gunston Hall, about 25 miles below Little Falls Dam (Mansueti and Hollis, 1963; Walburg and Nichols, 1967).

Success in reestablishing runs of anadromous fish above Little Falls Dam, therefore, may require the transplantation of fertilized eggs from the lower to the upper river to build up a population that will have the instinct to move above the dam each spawning season. Successful hatching of shad eggs in the river above Little Falls and collection of young shad in the Little Falls pool indicated that the area can support runs of shad.

The fishway, with its auxiliary water supply and stoplog feature for controlling the attraction water, is an excellent facility for the study of the behavior of the anadromous fish; findings could have immediate application in the planning of fish passage elsewhere. The experience gained can provide guidelines for continued studies.

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